

LLNL/DOE Individual Radiation Monitoring kin armij in jukjukin bed eo an aelon in Enewetak ilo kotaan 2001–2002: An Overview

LLNL/DOE Individual Radiation Protection Monitoring of Enewetak Island Residents during 2001–2002: An Overview

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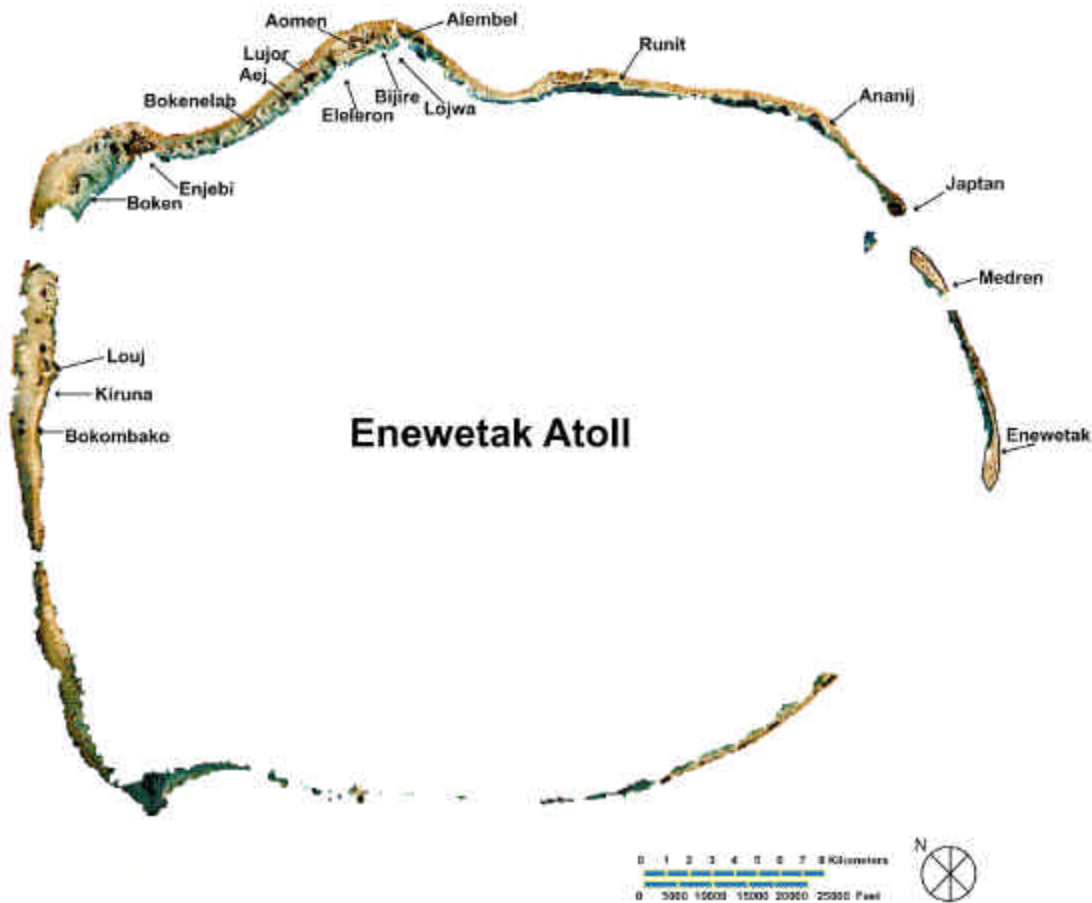
(for further information, visit <http://en-env.llnl.gov/mi/>)

Community Meeting November 2002

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INTRODUCTION (Kebellok)

United States eo ear kōmanne joñan in 43 kōmelmel in baam ko mejatoto ilo Enewetak ikōtan 1948 manlok ñan 1958. Enañin aolep test kein kar kōmman iion tawōr im baaj ko turear tuiōñ in aeto ko im kar jebar level in local fallout ko relap ilo an wōtlok iturin jekein test kein kar kōmman ie. Men ko jet kar walok tokjen program in kōmelmel kein ej, bwidrej ko rar jako, mweik ko jorren itok wōt jen kar makitkit in ekkal, im jikin ko kab resource ko einwot emōj kōmman mo ñon kejerbali. Aelon in kar wōnmanlok wōt im kejerbale ñon kajojo kain program in bōbrae ko mae 1997. Armij in Enewetak ro kar kōmakit er ñon Ujelang, ijo rar koppad ie mokta jen an kar jino program in kōmelmel eo, im kar jab jino aer rol ñon ailōñ eo mae 1980.



KOMELMEL KO ILO EBEBEN EO MAN

Komja eo an Trusts Territory eo an Ailiñ in Pacific kein kar lelok maroñ ñon karreo im resettlement (bar jokwe) e Enewetak ilo 1973. Ear jino jermal in karreo ko ilo 1977 im kar kōmman bwe en jobbij joñan in 100,00 yards³ in bwidrej ko ion ene, jen Enjebi, Lujor, Runit, Aomon im Boken Cactus crater ilo Runit. Ke ej dredrelok, juōn roñ in bontang (boom) 30 ne mulalin kar bōk jikin kin juōn dome eo emōj kil mejen kin jimen eo im ej 25 ne aetoken im 370 ne belakin. Department of Energy ej kōmman jermal in etale ko belakin Runit jen iien ñon iien ñon etale kautata ko im maroñ bed ilo juōn iien eo aetok itok jen joñan eo bed wōt jen level in plutonium ilo bwidej im/ak makitkit in radionuclides ko jen dome eo lok ñon lojet.



INDIVIDUAL RADIATION PROTECTION MONITORING

Brookhaven National Laboratory eo kar jinontata bōk eddo ñon letoletak individual radiation protection monitoring ñon ro uuan jukjuk im bed eo emōj aer rol (1980-1997). Wawen jerbal in kar itok ilo kajojo iien ko im ilo tōre in mission ko im kar drik joñon eo kar lelok non kemouri local resources im infrastructure. Ilo tōre in, emōj an U.S.

Department of Energy (DOE) kadedeik lok jet wawen kelajrak ko ñon jino konono kake aikuij ko an Enewetak ikijien radiological surveillance. Plan in ej ñon kwalok melele ko ñon kobaik tok rijerbal ro emōj aer hire im traini er ñon kōmmāne radiation protection monitoring im jerbal ko einwōt ñon jukjuk im bed eo. Kōtmene wōt ke program in monitoring in ekel enaj kalikar ke doses ko maroñ buki jen jermatmat in residual fallout contamination naj bed wōt ilo level ko ak ilalin level ko emōj kili, kwalok melele ko bwe jukjuk im bed eo en jela, kōmanman lok wawen konono ko im kalablok level in cooperate eo ibben ro mōtami ilo DOE.

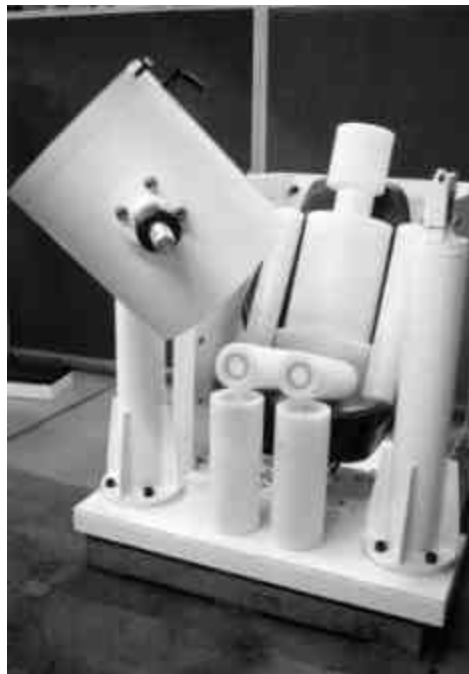


Enewetak Radiological Laboratory eo. Laboratory in ekel, ej lukkun ijo jikin whole body counter eo im bar einwōt juōn jikin joke eo erreō ñon aljek im kamadmōd bioassy sample ko. Program in whole body count eo ar jino kitien ilo May 2001. System in bwinbwin in emaroñ jerbal itok wōt jen kamadmōd an technician ro emōj hire im traini er einwot health physics. Scientists ro jen Lawrence Livermore National Laboratory rej jerbal ibben technician rein im nawaween training ko rellap lok, kilen kamadmōd system kein im data quality eo ebolel.

WHOLE BODY COUNTING (Bwinbwin in aolepen einbwin)

Juōn men eo elap an armij ro joke ilo Enewetak abnōnō kake, itok wōt jen kōkmalmel ko, ej an maroñ dreloñ cesium-137 ilo einbwin itōk wōt jen mōña ko kaddōki ion ene. Joñan cesium-137 im emōj an dreloñ einbwinin armij maroñ lukkun jijet etale ilo kejerbal juōn kain kilen bioassay na etan whole body counting (bwinbwin in aolepen einbwin).

Whole body count system eo ion Enewetak ej drebij juōn sodium iodide detector eo elap ñon joñe gamma-emitting radiation kar bōki ilo einbwin. Whole body counter eo ej bedbed wōt ion 'Masse Bolton Chair' eo. System in maroñ loe joñan energy gamma-emitting radionuclides ko routiej einwot cesium-137, cobalt-60, im potassium-40 ilo enañin aolep jabok in einbwin im organ ko ituloa. Kain bwinbwin kein maroñ ukōti ñon dose ilo kejerbal jet kain design in computer software program ko jen kōmadmōd ko lal in emōj an kili. Enan eo ñon ro rej joke ion Enewetak bwe ren bōk whole body count eo, driktata juōn alen ilo juōn iiō. Dri jerbal in agriculture ro naj loñ lok kōtan bwine er itok wōt jen ad anton e lok ke enaj lab lok level in cesium-137 ibbeir itok wōt jen jerbal eo aer.



Whole Body Counter eo. Whole Body Counter eo ej walok ijin ibben juōn calibration phantom eo ilo jea eo. Calibration phantom eo ej jerbal ñon lale joñan eo detection system in ej kwalok bwe en alikar ke joñjoñ ko buki rej jijet im waibben.

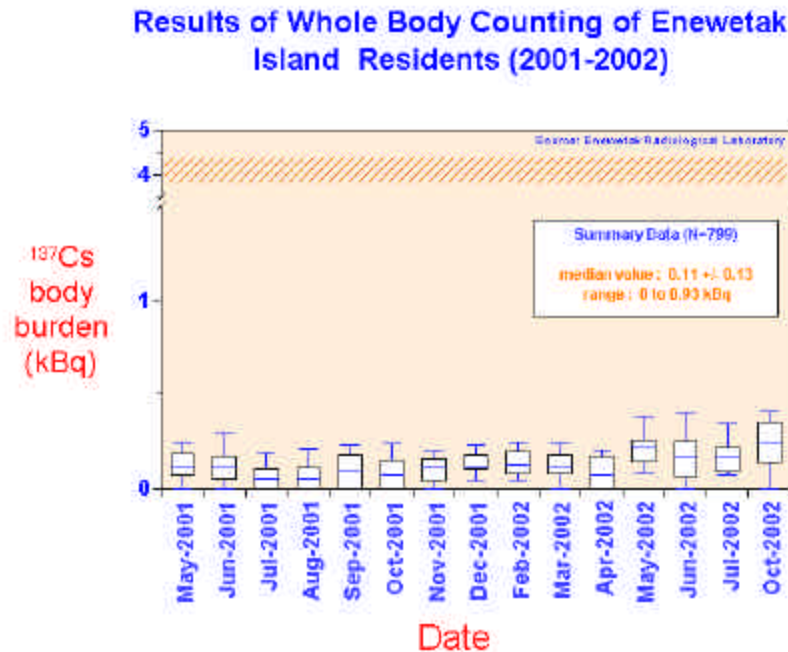


Enewetak Whole Body Count technician ro, Kosma Johannes im Donald Henry kar bōk trainin ko aer jen Dr. David Hickman eo im ej jen Lawrence Livermore National Laboratory.



Mr. Toshio Ken ej eo mōktata kar register einwōt juōn eo ear bōk kunan ilo Enewetak whole body counting program.

TA EO JEMLOK KEIN REJ KWALOK?

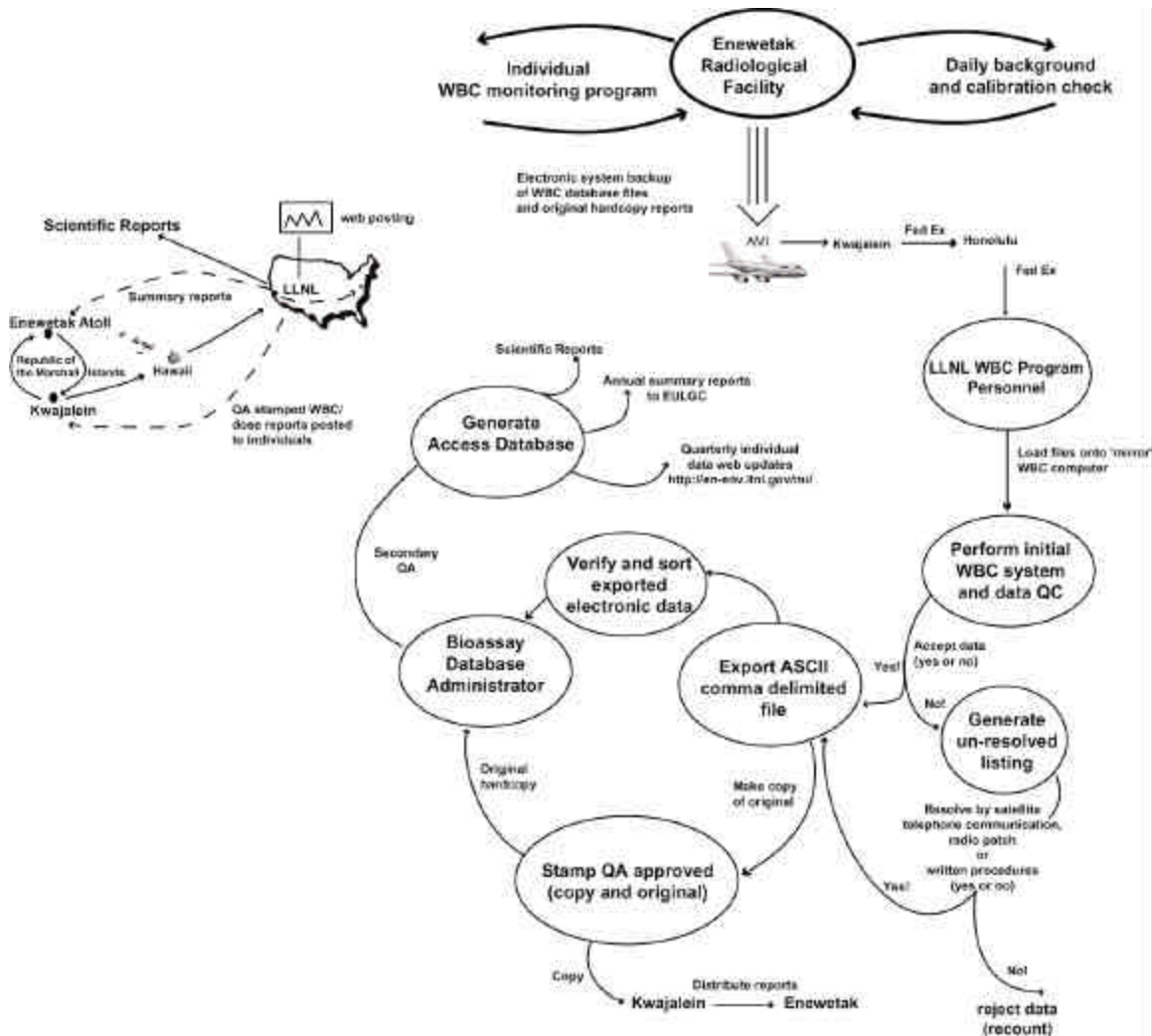


Joñak in data ko jen whole body count program eo ilo Enewetak Atoll (May 2001- ñon iien in).

Joñan level in cesium-137 loe iloan enbwin armij ej kawalok ilo unit in kiloBecquerel (kBq) ko ion vertical axis in. Horizontal axis in ej kwalok ran in bōk sample ko jino jen May 2001. Maan lok ñon July 2002, dri jermal ro an whole body count kar maroñ kōmmane ebaklok 800 bōnbōn ko ñon 470 armij ro ilo jukjuk im bed eo. Ejañin wōr oktak ko rellep ak spike ko ilo joñan cesium-137 kar lo ilo kōta in. Wawen in kar maroñ jiban kim jolok lemnak ko mokta ke armij ro remaroñ kar bōk spike ko kon joñan ko relōñlok in cesium-137 jen mōña ko buki im kani jen ene ko tueañ, im dose in mottan maroñ kar jab lo ilo program in etale ko manlok. Jouij im melele ilo eñanin aolep keij (joñan 25% in aolep bwinbwin) kein, kemij jab kar maroñ lo cesium-137 ilo armij.

Copy in jemlok ko jen whole body count eo rej jilkinlok ñon Lawrence Livermore National Laboratory ijo scientists (rimeletlet) ro renaj etali aurōk in data kein im kwalok juōn repot eo etijemlok. Armij ro ilo ailiñ eo im kar bōk juōn whole body count eo ej kwalok cesium-137 maroñ naj kōmmane juōn pepe eo emelele kake kin wawen iminene in mōña ak kilen mour drebdreb wōt ion ta eo watōk ke emman ak joñan eo kile ke maroñ bōk ekkar ñon ejmour. Whole body counting eo ej kwalok juōn bōnbōn eo ejijet kin radionuclides kajojo maroñ dreloñ ilo ro uuan ailiñ eo. Melele ko ñon ta eo juōn armij ej buki im joñan eo kōtmene ke kauwōtata ñon ejmour maroñ etali kin data ko emōj joñi im jab kin anton ko rej drebdreb wōt kin men ko dreloñtok im ejelok melele kaki.

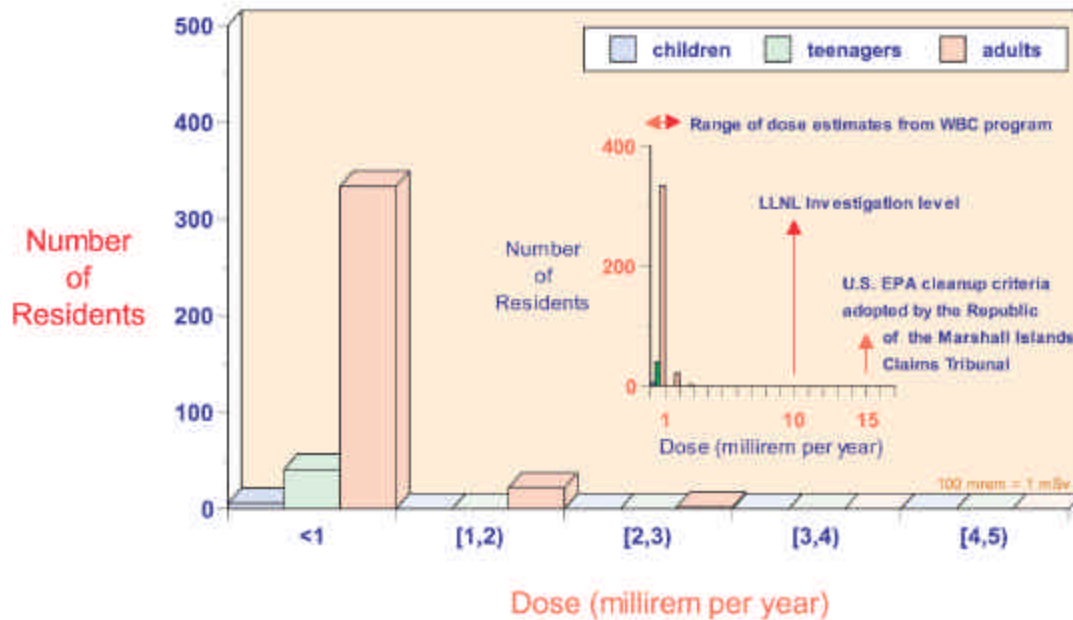
ENEWETAK DATA QUALITY CONTROL



Outline eo an Enewetak Data Quality Control Process. Scientist ro jen Lawrence Livermore National Laboratory kar kōmman jet kain kelajrak ko ñ on jibañ kwalok juōn wawen eo eweppen ñon aljek data im tibdriki. Data eo ej rol ñon Lawrence Livermore National Laboratory ijo im enaj kōmman data quality eo etiljek, im melele kein naj kejbaroki ilo juōn electronic database system eo ñon kajeded. Data in im emōj letoletak ej bed wōt ilo jekjek eo etino ñon kejparok etan ro kajojo rej bōk kunair ilo program in. Aolep joñak in data kein im melele ko ibben tok ej driwōjlok ilo report ko ilo juōn iōō im likit ilo world-wide web eo ak <http://en-env.llnl.gov/mi/>.

ANNUAL INTERNAL DOSE

Internal dose to Enewetak residents from dietary exposure to ^{137}Cs during 2001



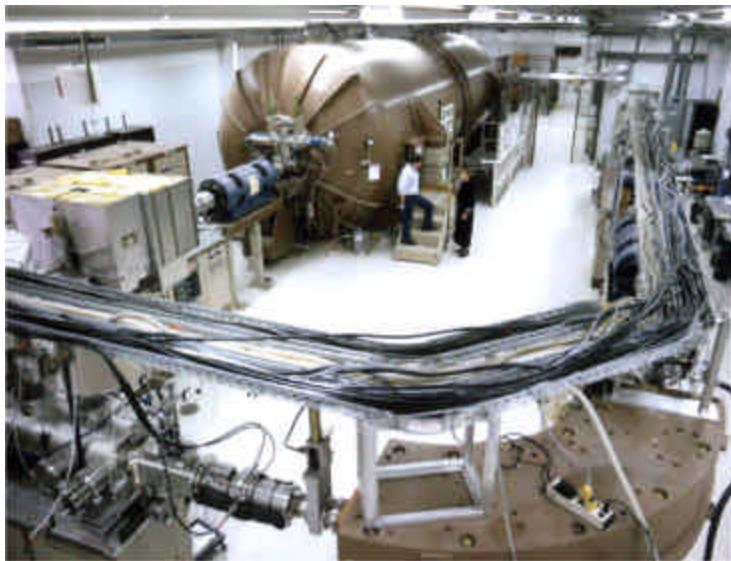
Joñan dose eo tuloa ilo juōn iiō ñon ro re jokwe ilo Enewetak jen jermatmat ko jen cesium-137 itok wot jen wawen moña ko (May-Dec.2001)

Whole body count data eo ej kwalok ke enañin aolepen armij ro jokwe ilo ailiñ in Enewetak emōj bōk juōn dose eo im ej drik lok jen juōn mrem juōn iiō. Jen ba, dose eo armij ej bōk jen an drelon cesium-137 iloa elukkun in ettā. Kajojo dose ko emōj keidi ñon dritto (358 dritto ro), ro emman dred (41 jodrikdrik), im ajri ro (6 iaer), iuumin 2001 iiō eo ej 0.4 ± 0.4 , 0.2 ± 0.2 im <0.1 mrem juon iiō ilo kautiej wōt.

Dose kein antooni ban kwalok kautata eo jemaroñ joñe ak melele kake.

PLUTONIUM URINALYSIS MONITORING

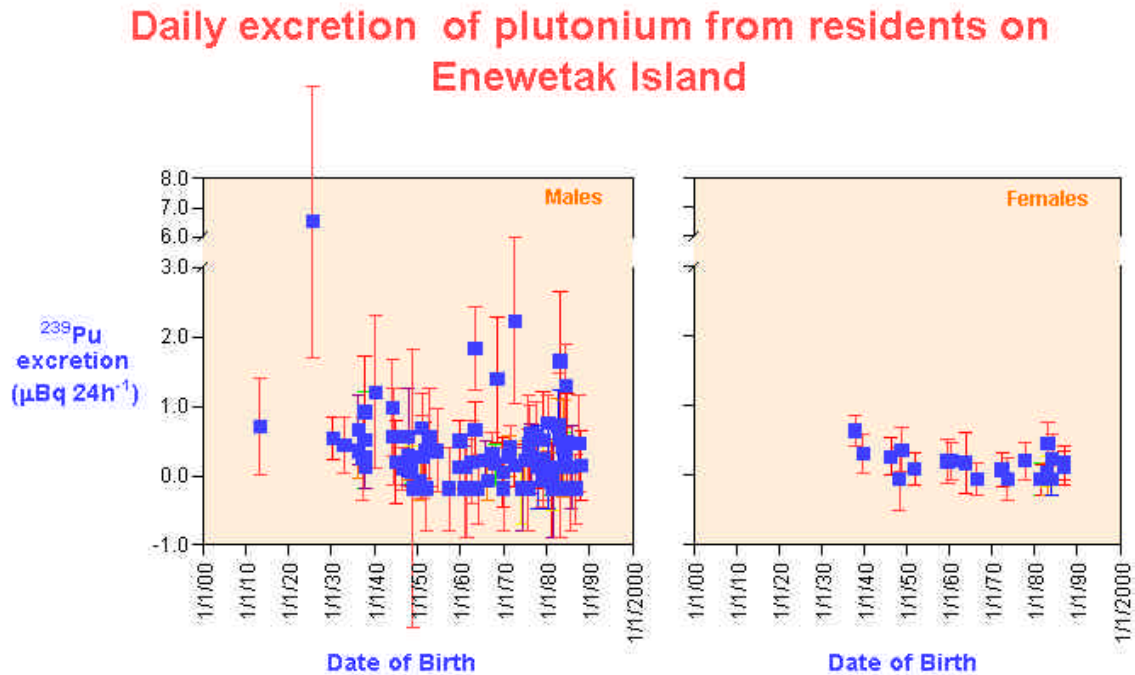
Plutonium ej juōn radioactive element eo elap tokjen im ej rōlok jen drebolok in nuclear (bomb) ko. Plutonium ej kōtlok ilo aer makitkit wōt jidrik jet men drikdrik ko im rekajur na etair alpha particles (ak alpha rays). Alpha ray ko rej makitkit jet wōt inij ilo mejatoto im maroñ kabwijraki kin juōn pepa ak kil eo tulik emej. Jorren ko im maroñ walok ñon ejmour jen plutonium ej itok jen an tuloa jermatmat kin plutonium itok wōt jen emenono ik bwinal ko re-paijin ak jen bok/bwidej ko re-paijin ilo aer dreloñ enbwin. Bioassay sample ko kar aljeki ilo Enewetak Radiological Laboratory ilo an erreō jikin jerbal naj jilkinlok ñon Lawrence Livermore National Laboratory ñon kamodmōdi. Juōn kain system in kabbok eo im etijemlok ñon joñjoñ plutonium dredrelok kōmmāne ñon wōt Marshall Islands Urinalysis program eo.



Center eo ñon Accelerator Mass Spectrometry (CAMS) ilo Lawrence Livermore Laboratory eo ej juōn jikin eo elukkun bolel ñon kwalok kabel ko ñon maroñ lo jōñan level ko rettā non joñe plutonium ko ilo bioassay samples ko. Accelerator based measurement technology in elukkun bolel ilo an maroñ joñe doses ko im dredrik lok jen 0.02 mrem juon iiō. Ilo joñan level in im ej kwalok, jemaroñ joñe jermatmat ko ñon plutonium im ej 7000 alen driklok jen joñan eo armij ejjab maroñ bōbrae, jen aer bōk jermatmat jen radiation ko rejjab kauatata ilo belak.

Technology in ebolel ej jerbal ilo Livermore ñon jepake Enewetak urinalysis program eo im mōj an lukkun le jen aolep requirement ko ñon occupational monitoring programs ko ilo United States.

TA JEMLOK KO PLUTONIUM URINALYSIS EO EJ KWALOK?



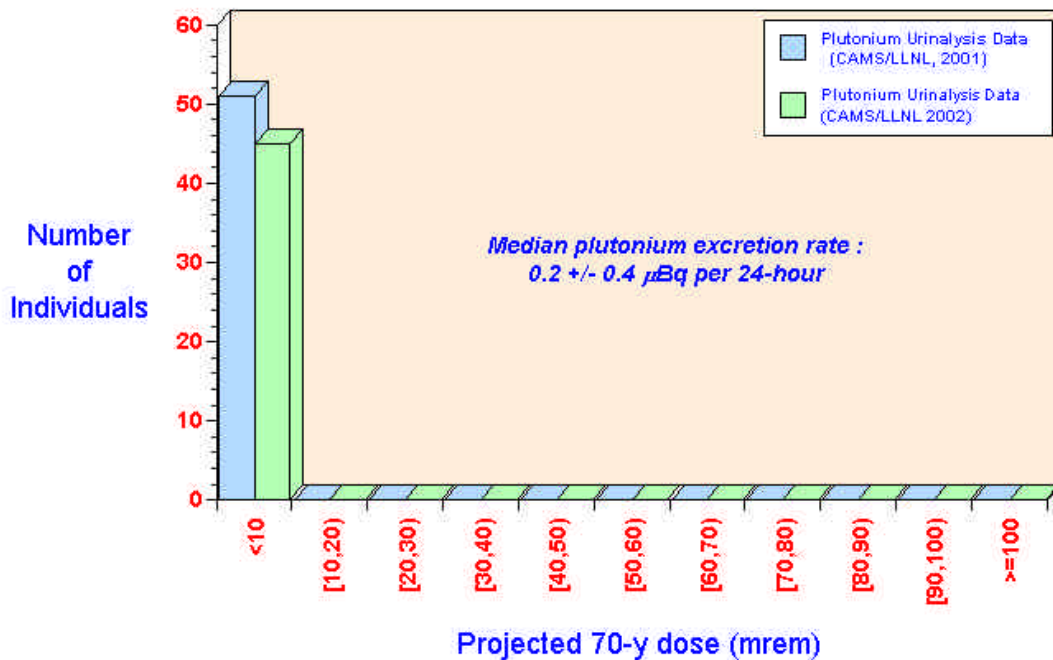
Joñan urinary excretion in plutonium jen ro jokwe ilo Enewetak. Vertical axis eo ej walok measurement data ilo kajojo microBecquerel (μBq) juōn ran. Horinzontal axis eo ej kwalok iioō eo an kajojo ro kar test kin symbol ko rejonolok ñon emman im kōra.

Ejañin wōr kamol ke incremental intake in plutonium ej mōttan wōt resettlement eo an ailiñ in Enewetak.

Kar antoone ko moktalok ikijien background increment rate in plutonium ko jen dritto ro ilo ene ko tuiōñ in Marshall Island ekkā an 1 ak 2 μBq juōn ran. Jemlok ko ad rej drebdreb wōt ilo aer ettā jen joñan kein. Menin ej kemalij lok ke joñan level in jermatmat ko jen plutonium ilo Enewetak rejjab drik wōt ak, ñon ro im kar test e er, jemaroñ ba rej jab maroñ kar etal ñon ibbeir joñan jermatmat ñon plutonium jen aolep intake ko mokta lok. Data eo im melele eo emōj kwalok jen program in urinalysis eo ilo Enewetak naj jijet ñon kejerbali ñon kwalok juōn local baseline bwe en lukkan allikar joñe aurōkin wawen plutonium intake ilo an ejja mōttan wōt resettlement in ene ko jet ilo ailiñ en.

REMANLOK 70-IIō IN DOSE EO ñON RO REJ JOKWE ILO ENEWETAK JEN AN WOTLOKTOK PLUTONIUM ITULOA.

Projected 70-y dose to Enewetak Island residents from internally deposited plutonium

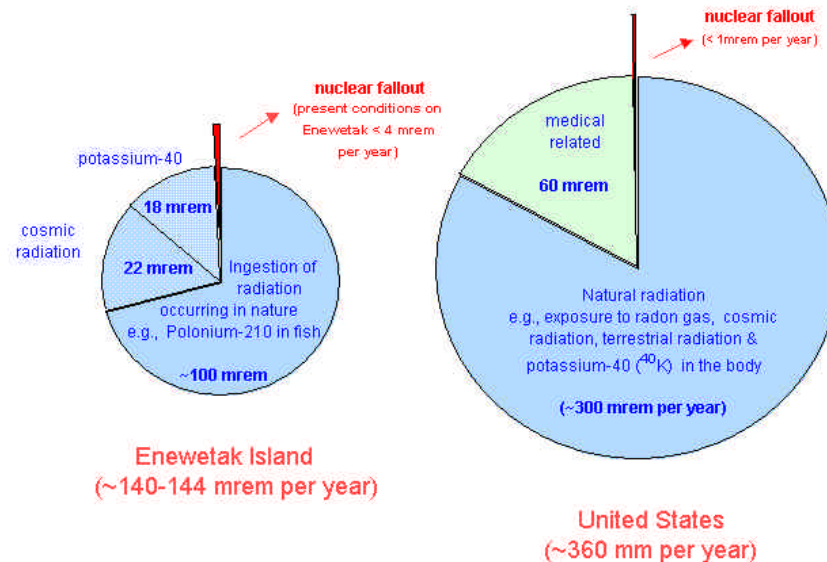


Joñan plutonium eo kar lo ilo bioassay sample ko buki jen kebak 100 armij ro kajojo ilo 2001-2002 kar wõtlok ak bed iumin level eo eaboñ in lo ñon joñak ko. Ilo jekjek in, jeban aikuij kur ñon report e juõn dose; bõtáp, jenaj antoone lok dose eo jen plutonimej jiro. Ñon likio in, dose kein wanjoñaki emōj kadreloni ilo report ko am. Lifetime dose eo remañlok kake jen jermatmat ñ on plutonium ñon kajojo ro kar test e er ion Enewetak ej bed iumin 10 mrem ion (ilo?) 70 iioo.

Dose kein emoj antooni ban joñi ak kwalok men ko kautata ñon ejmōur.

KEIDI RADIATION DOSE KO ILO MARSHALL ISLANDS IM UNITED STATES

Exposure to natural and man-made sources of radiation



Dose in armij buki jen an dreloñ cesium-137 ilo enbwin jen mōña ko kadreki ijokein aikuij likit ilo juōn wawen eo alikar. Ñon waan joñak, potassium ej juōn men eo aikuiji ñon mour, ak ebar walok ke eor radioactive ie. Potassium-40 eo im ej make walok im ebed ilo enbwin ej letok joñan in 14 mrem ñon joñan dose eo jej bōk ilo juōn iiō ejja ilo wawen eo wōt ikijien cesium-137. Juōn medical X-ray eo im ekkā an aolep bōke enaj kwalok juōn dose in joñane 6 mrem.

Joñan aolepen dose eo itok wōt jen ibelakid ilo Marshall Island ej 140 mrem ilo juōn iiō im joñan in bōke ej itok wōt jen an lap ad mōña eek ko rekel im ear wōr wōt polonium-210 ie. Armij in United States elap lok natural radiation dose eo rej bōke kin joñan in 300 mrem ilo juōn iiō. Joñan eo elikio im ekautata ñon ejmour jen jermatmat in radiation enaj walok jen kōbaik ko itok wōt jen belakir (natural) im dose ko kōmman jen armij. Joñan dose eo ituloa emōj antoone jen ro rar bwinbwin, im ej itok jen cesium-137 eo im emōj joñe ilo enbwinin armij in Enewetak, ej drik lok jen 1% in aolepen natural background dose eo aer.

Dose eo ituloa jen cesium-137 ion ailiñ in Enewetak ej bareinwot weippen im bed wōt ilalin joñan eo emōj kōtmene ikijien wawen karreo ko im ej 15 mrem ilo juōn iiō im Republic eo an Marshall Island ear bōk bwe en mwein. Agency ko jen belak in lal in kar kile juōn wawen eo ejjab meralok kon joñanin in 100 mrem tuloñin background eo ñon kejbarok ro uuan lobwilej.

GLOSSARY OF TERMS

Becquerel (Bq)

Juōn becquerel (tukadu I ej Bq) ej International System (SI) unit eo ñon makitkit ko an juōn men eo ej radioactive. Juōn Bq in men ko rej radioactive ej joñan men eo im juōn atom ej jenij ak bōk juōn decay aolep second.

Calibration

Juōn Wawen kajimwe uuak eo an juōn kein jerbal ñon kwalok reading ko rejijjet.

Critical Level

Joñan oran numba in bwinbwin ko ilo ak iloñin wawen eo juōn decision ej kōmman ke juōn radioactive material ej lukkun alikar ke ebed.

Dose Equivalent

Dose equivalent ej dose eo bōke ilo ad jela kin biological effectiveness in radiation ñon an maroñ kwalok jorren.

High End Health Risk

Ej kwalok joñan eo elap juōn armij naj bōk jermatmat ilo juōn population.

Internal Dose or Exposure

Mōttan dose eo einwot joñan eo bōk jen radiation source ko ilolan enbwin.

Individual

Kajojo armij.

Isotope

Juōn atom jen ejjā element eo wōt im eōr oktak drik ko ilo atomic mass eo ie. Jej kile isotopes ko roktak ilo kobaik juōn nōmba eo ej kwalok drebio in isotope eo ñon etan element eo. Juōn example ej cesium-137 eo im ekkā ilo tukaru, ^{137}Cs , ijo ej kwalok chemical symbol eo ñon cesium ej Cs.

Quality Assurance

Bunten ne ko buki ñon drebij juōn wawen joñjon eo ñon kalikar rej bed wōt ilo jekjek eo emoj kwalok.

Radiation Dose

Radiation Dose ej juōn generic tōrm kejerbale ñon antoone radiation eo maroñ kwalok jorren ko ñon ejmour im ej ekkā an walok ilo unit in mrem ilo juōn iiōō.

Radioactivity

Juōn natural ak spontaneous process eo ej kwalok atom ko rejjab kon ilo juōn element ilo aer kadruwojlok energy im/ak mendrikdrik ko, im jenij (ak makunlok) ñon juōn element eo eoktak ak isotope ko roktak ilo ejjā element in wōt.


Appendix 1

Individual Annual Dose Report

Aoleb volunteer ro rar bok juon aer individual (kajojo) annual (juon yio) dose report ilo yio ko kajojo im rej bed ilo program in whole body counting ak plutonium urinalysis.

Sample in dose report eo ej walok itu-lal.

Report in ej kwalok kin annual (yio) dose eo kajojo rekar bok ilo yio en. Dose in emaron lale ta oktak ibben juon natural background dose kin 140 mrem ilo Marshall Islands (ak rebed ibben armij ro ilo Marshall Islands). Report in ej bareinwot koba juon copy kin aoleben verified measurement data eo me ej jermal non jone jonan dose eo.



Lawrence Livermore National Laboratory
HEALTH & ECOLOGICAL
ASSESSMENT DIVISION

October 21, 2002
ID# «PersonID»En Am Makma:

NOI: «First Name» «Last Name»
IEN: Dr. Terry Hamilton
Marshall Islands Program Leader
Lawrence Livermore National Laboratory
UN EO: Report in jermal in Etale Jonan Baijin.
Dear eo ej Bok Konam:
Imecoto in likil jin juon copy in report in jermal in etale jonan dose in baijin eo an makma ilo im
eo maantak non 31 December 2001 (lale meke ko jin).
Department eo an Energy kobalak ibben rijerbal (technicians) in aelos kiti ro im komon jermal in etale
juon dose eo (ne ewor) ilo enbwinom ilo as kjerhal krenadmod in Whole Body Counting (WBC) non
lale elane ewor ebwan 137 ase dezin ilon enbwinom. Jonok kein (data) kar tobet kar kobaiki iben
dron im ukol im jaoe wof dose ilon enbwin non juon yio einwot an walok jin ilal. Kim kar bareinwot
ebok, drem in kabbyok (mat) jin rijerbal ro non komon jermal in etale elane ewor an ear ejednatmat
non plutonium (ne ewor) jin majatoto eo kwoj emenoniki. Elane kwalok jonan deetee kein jinec
inem dose eo ilon rebwin non juon yio einwot an walok ej koba in dose ko an im kar unnilok.
JONAN DOSE EO ERED ILO ENBWINOM ILO YIO IN 2001, KAR ANTONELOK IIWE EJ
«Total_Dose_2001» millirem (mrem).
Jonan in elab in dikiok, jin jonan dose eo ebwan ri Amerika kan rej kore eo im ej 100 mrem juon yio
non aolep armij, im ediklok jin 15 mrem juon yio eo im Republic eo an Marshall Islands ear kile.
Kin mien, ekar non jekjek im wewen an bed im mearjermal ej alikar bae ewe kein bome baijin in
raifaten ko liwoj non yik.
Kommol kin an bok konam.

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Individual Radiation Monitoring Report

Personal ID	Last Name	First Name	Address
0000000	Doe	John	Lawrence Livermore National Laboratory P.O. Box 808 Livermore CA 94539 United States of America

Internal Dose Report

Year	Cesium-137		Plutonium-239		Plutonium-240	
	Annual Dose	CEDE*	Annual Dose	CEDE*	Annual Dose	CEDE*
	mrem	mrem	mrem	mrem	mrem	mrem
2001	15.0	21.0	0.00	0.0	0.00	0.0

*CEDE=Committed Effective Dose Equivalent over 70 years.

The amount of radiation a person receives is called the 'effective dose equivalent' and is measured in thousandths of a rem (called the millirem) and is abbreviated or shortened to mrem. Your internal dose from ingestion of cesium-137 and inhalation of plutonium-239 has been converted into a single internal annual dose and a CEDE as shown above. This compares with an estimated Marshall Islands background dose of 140 mrem/year. The international scientific community has adopted the use of a different term for millirem called the millisievert (mSv). A millirem is the same as one-hundredth of a mSv.

Cesium-137 Internal Monitoring Data

Whole Body Counting (WBC)				Uncertainty Range	
Date of Count	Nuclide	Unit	Activity	Maximum	Minimum
5/21/01	Cesium-137	kBq	4.20	4.62	3.78
6/28/01	Cesium-137	kBq	4.20	4.62	3.78
9/10/01	Cesium-137	kBq	4.20	4.62	3.78
10/12/01	Cesium-137	kBq	4.20	4.62	3.78
12/12/01	Cesium-137	kBq	4.20	4.62	3.78

Plutonium Internal Monitoring Data

Plutonium Urinalysis (Pu in urine)				Uncertainty Range	
Date of Collection	Nuclide	Unit	Activity	Maximum	Minimum
8/1/01	Plutonium-239	uBq/24 h void	0.0	0.0	0.0
8/1/01	Plutonium-240	uBq/24 h void	0.0	0.0	0.0

Plutonium analyses were performed by the Center for Mass Spectrometry at the Lawrence Livermore National Laboratory using the new state-of-the-art measurement technology Accelerator Mass Spectrometry (AMS). Accelerator mass spectrometry is about 100 times more sensitive compared with classical bioassay monitoring techniques. The results show that levels of plutonium in your urine are within the normal worldwide background range.

LLNL/DOE Individual Radiation Protection Monitoring of Enewetak Island Residents during 2001–2002: An Overview

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and
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(for further information, visit <http://en-env.llnl.gov/mi/>)

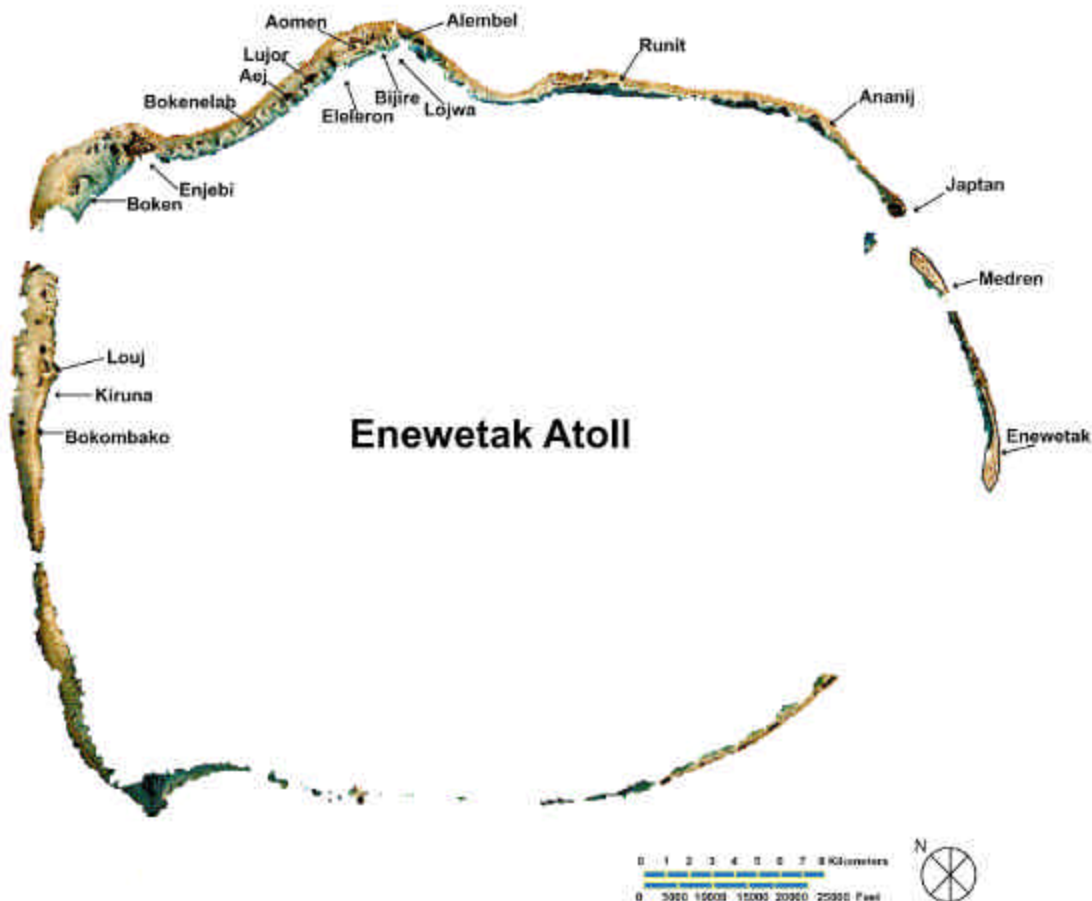
Community Meeting November 2002

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INTRODUCTION

The United States conducted a total of 43 atmospheric nuclear tests on Enewetak between 1948 and 1958. Most nuclear devices were detonated atop of towers and barges in the north and northeastern quadrant of the atoll and produced high levels of local fallout deposition within the immediate vicinity of the test sites. Other direct effects of the nuclear testing program included loss of land, property damage from construction activities, and restricted use of land and associated resources. The atoll continued to be used for various defense programs until 1977. The people of Enewetak were relocated to a temporary home on Ujelang Atoll before the test program began and did not begin to return to Enewetak until 1980.



POST TESTING ERA

The Governor of the Trusts Territory of the Pacific Islands granted authority for cleanup and resettlement of Enewetak Atoll in 1973. Cleanup commenced in 1977 and involved the disposal of over 100,000 yards³ of surface soil from Enjebi, Lujor, Runit, Aomon and Boken in Cactus crater on Runit Island. On completion, a 30-foot deep bomb crater was replaced with a concrete capped dome 25 feet high and 370 feet in diameter. The Department of Energy are providing periodic environmental monitoring on and around Runit Island to assess the long-term hazards posed by residual levels of plutonium in soil and/or migration of radionuclides from the dome into the marine environment.



INDIVIDUAL RADIATION PROTECTION MONITORING

The Brookhaven National Laboratory (BNL) were originally responsible for providing individual radiation protection monitoring for the resettled population (1980-1997). This work was periodic in nature and mission oriented with little consideration given to developing local resources and infrastructure. More recently, the U.S. Department of Energy (DOE) has implemented a series of strategic initiatives to address the long-term radiological surveillance needs on Enewetak. The plan is to provide meaningful involvement of locally hired and trained technicians in supplying radiation protection monitoring and related services to the community. It is expected that this new monitoring program will demonstrate that doses from potential exposures to residual fallout contamination remain at or below acceptable levels, provide necessary assurances to the community, improve communication and enhance the level of cooperation with DOE counterparts.



The Enewetak Radiological Laboratory. This new laboratory facility houses a permanent whole body counter as well as clean living space for collection and handling of bioassay samples. The whole body counting program was initiated in May 2001. The counting system is operated and maintained by locally hired and fully trained health physics technicians. Scientists from the Lawrence Livermore National Laboratory work with the technicians and provide advanced training, systems maintenance and data quality assurance.

WHOLE BODY COUNTING

The main radiological concern for people living on Enewetak comes from ingestion of cesium-137 contained in locally grown foods. The amount of cesium-137 taken up in the body of people can be accurately assessed using a direct bioassay technique called whole body counting.

The whole body counting system on Enewetak contains a large volume sodium iodide detector that measures gamma-emitting radiation deposited in the body. The whole body counter is modeled on the 'Masse Bolton Chair' design. The system can detect high-energy gamma-emitting radionuclides such as cesium-137, cobalt-60 and potassium-40 in most parts of the body and all the internal organs. The counts are converted to dose using specially designed computer software programs developed from internationally accepted procedures. We have recommended that all residents on Enewetak receive a whole body count at least one time per year. Agricultural workers are counted more often because they are potentially exposed to higher levels of cesium-137 due to the nature of their work.



A Whole Body Counter. The whole body counter is shown here with a calibration phantom in the chair. The calibration phantom is used to test the response of the detection system to ensure that accurate and reliable measurements are made.

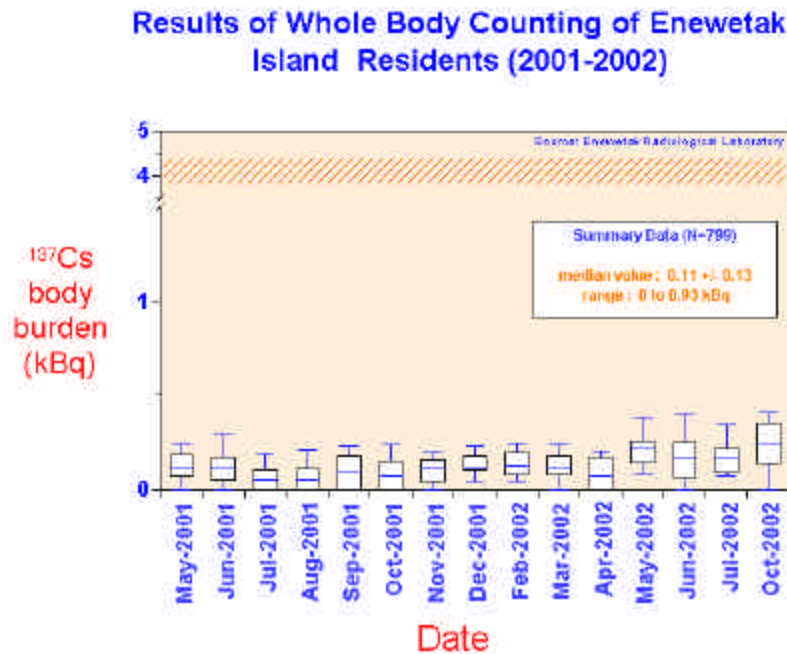


Enewetak Whole Body Counting technicians Kosma Johannes and Donald Henry receiving training from Dr. David Hickman from the Lawrence Livermore National Laboratory.



Mr. Toshio Ken, the first local resident registered as a participant in the Enewetak Atoll whole body counting program (May 2001).

WHAT DO THE RESULTS SHOW?

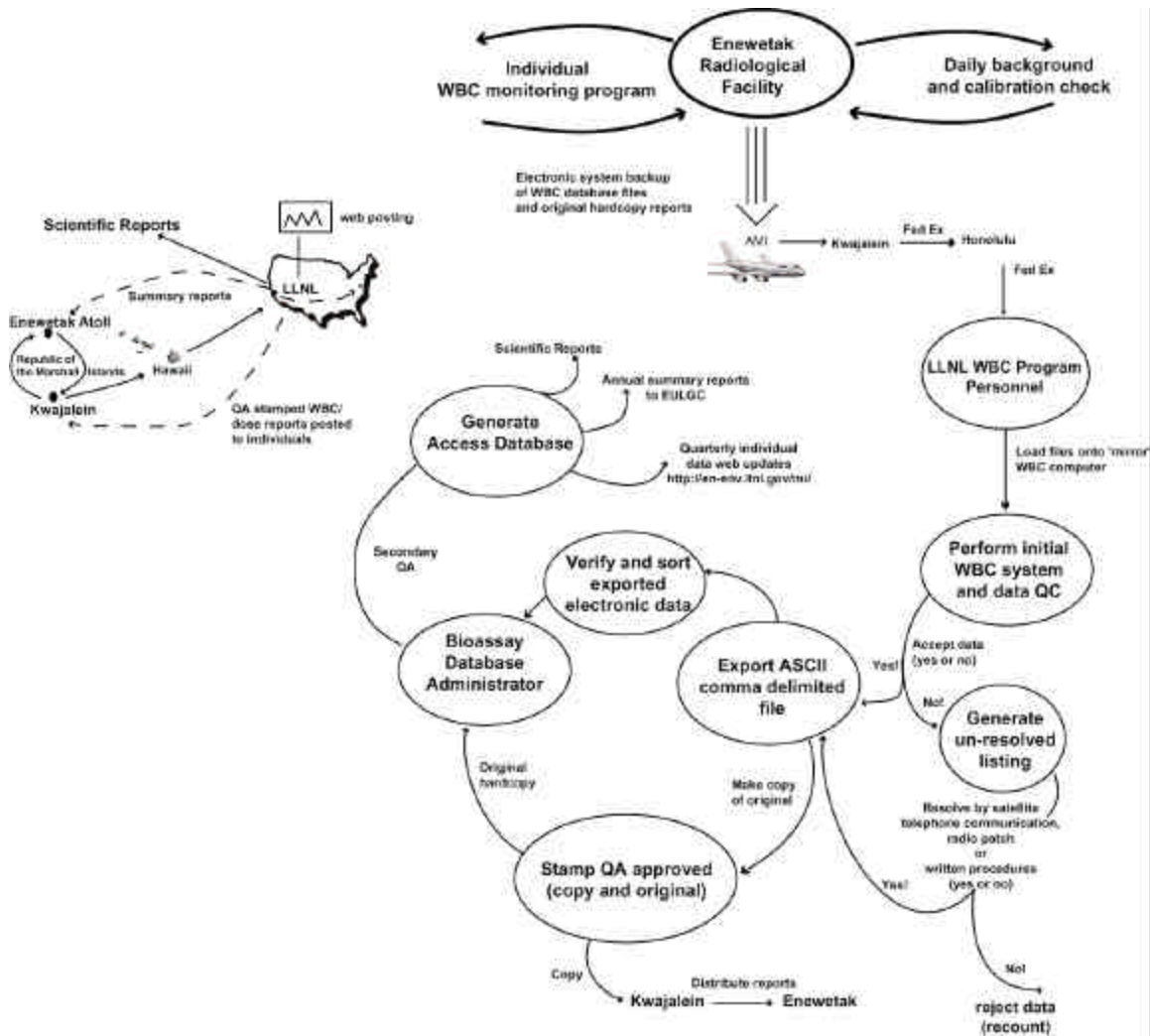


Measurement data from the whole body counting program on Enewetak Atoll (May 2001-present).

The level of cesium-137 found inside the body of people is expressed in units of kiloBecquerel (kBq) shown here on the vertical axis. The horizontal axis shows the date of collection beginning in May 2001. Through July 2002 whole body counting technicians have performed nearly 800 counts on 470 members of the Enewetak community. There have been no systematic changes or spikes in the amount of cesium-137 detected over this period. This helps us rule out earlier concerns that people may have been receiving incremental spikes in cesium-137 from eating foods collected from the northern islands, and that the associated dose was missed during earlier monitoring programs. Please note that in many cases (about 25% of all counts) we were not able to detect any cesium-137 in people.

Copies of the results of the whole body counts are forwarded to the Lawrence Livermore National Laboratory where scientists check the quality of the data and issue final dose reports. Local residents who receive a whole-body count showing the presence of cesium-137 can then make an informed decision about their eating habits or lifestyle based on what is considered a safe or acceptable health risk. Whole body counting provides a direct measure of the full range of radionuclide intakes in the local population. Information about individual intakes and potential 'high-end' health risks can be evaluated on the basis of measurement data rather than relying on assumptions based on a range of assumed intakes.

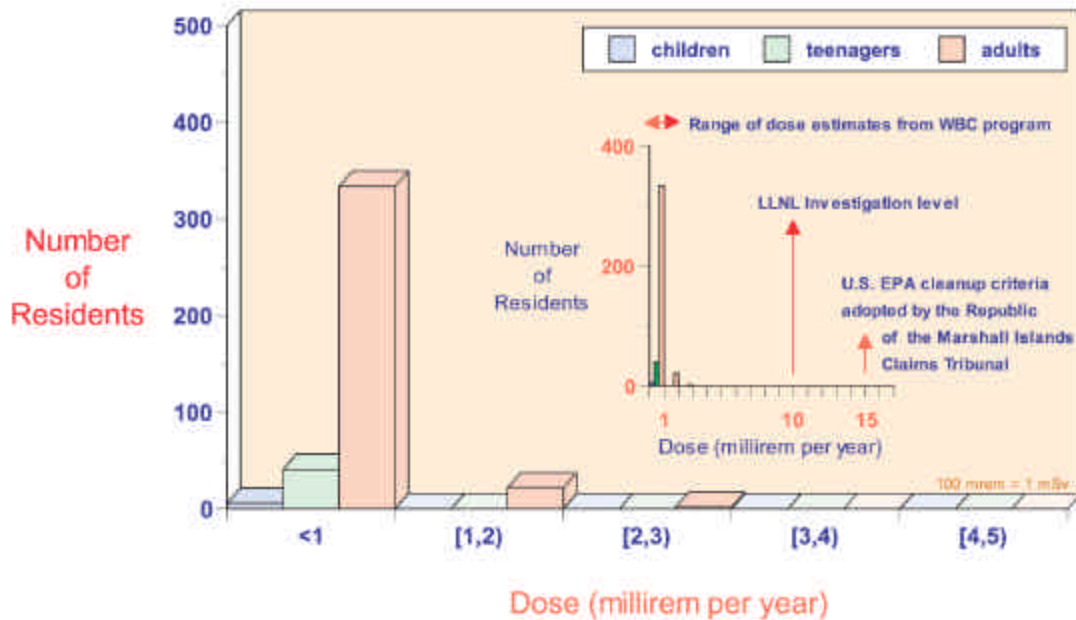
ENEWETAK DATA QUALITY CONTROL



Outline of the Enewetak Data Quality Control Process. Scientists from the Lawrence Livermore National Laboratory have designed special procedures to help ensure a high standard of data collection and analysis. The data is returned to the Lawrence Livermore National Laboratory where a thorough data quality review is performed and the information saved in an electronic database system for wider distribution. The distributed data is all deidentified to protect the names of individuals contributing to the program. All the measurement data and related information are released in annual reports, and posted on the world-wide web at <http://en-env.llnl.gov/mi/>.

ANNUAL INTERNAL DOSE

Internal dose to Enewetak residents from dietary exposure to ^{137}Cs during 2001



Annual internal dose to Enewetak residents from dietary exposure to cesium-137 (May-Dec. 2001).

The whole body count data shows that the vast majority of people living on Enewetak Island receive a dose of less than 1 mrem per year. That is to say, the dose that people receive from ingestion of cesium-137 is extremely low. The average individual doses to adults (358 individuals), teenagers (41 individuals) and children (6 individuals) during 2001 were 0.4 ± 0.4 , 0.2 ± 0.2 and <0.1 mrem per year, respectively.

The estimated doses pose no measurable or discernable health risk.

PLUTONIUM URINALYSIS MONITORING

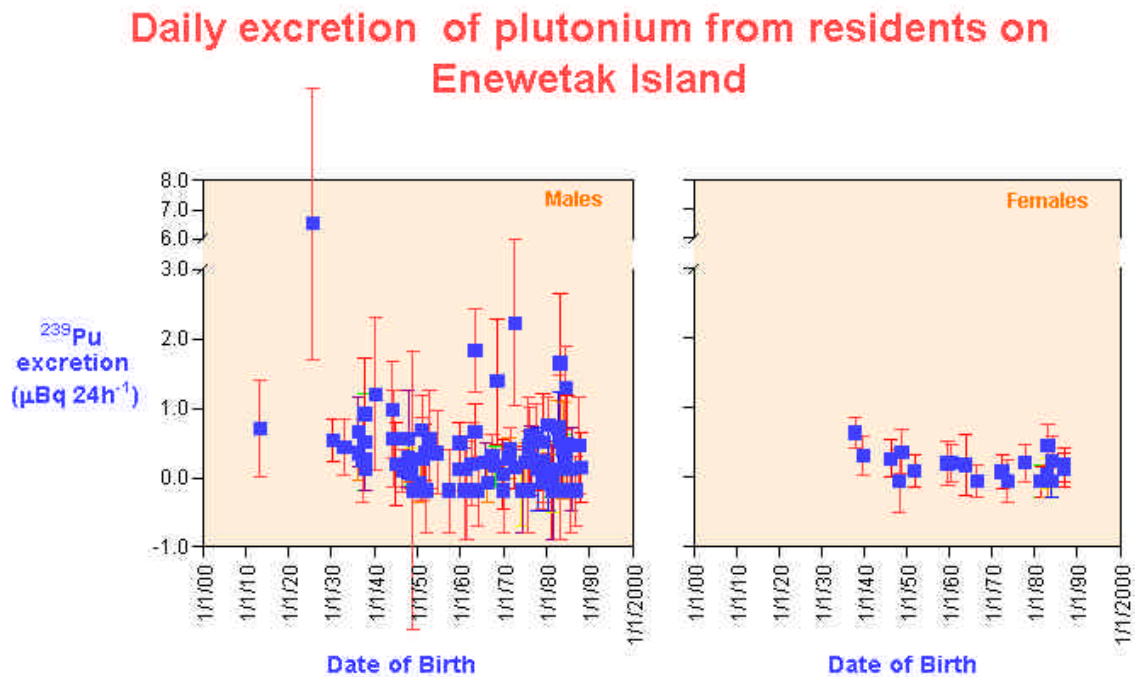
Plutonium is an important radioactive element released in nuclear explosions. Plutonium emits slow moving, heavy charged particles called alpha particles (or alpha rays). Alpha rays travel only a few inches in air and can be stopped by a piece of paper or the outside layer of dead skin. The potential health effects from plutonium come from internal exposure to plutonium resulting from the inhalation of contaminated dust in the air that people breathe or from ingestion of contaminated soil or food. Bioassay samples collected in the Enewetak Radiological Laboratory under clean environmental conditions are shipped to the Lawrence Livermore National Laboratory for analysis. A state-of-the-art detection system for measurement of plutonium was developed especially for the Marshall Islands urinalysis program.



The Center for Accelerator Mass Spectrometry (CAMS) at the Lawrence Livermore National Laboratory is a state-of-the-art facility providing a low-level detection capability for measurement of plutonium in bioassay samples. The accelerator based measurement technology is sensitive enough to measure doses of less than 0.02 mrem per year. At this level of detection we are able to assess exposures to plutonium that are 7000 times lower than what people unavoidable receive from exposure to natural sources of radiation in the environment.

The advanced technology used at Livermore in support the Enewetak urinalysis program far exceeds all requirements of occupational monitoring programs in the United States.

WHAT DO THE RESULTS OF PLUTONIUM URINALYSIS SHOW



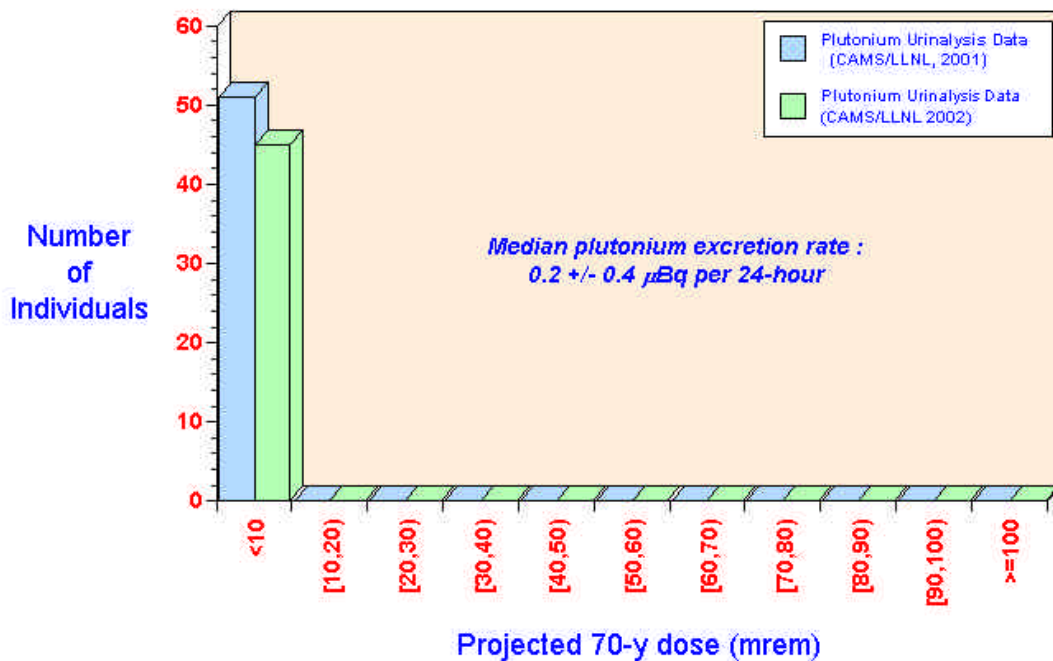
Rate of urinary excretion of plutonium by Enewetak residents. The vertical axis shows the measurement data expressed in units of microBecquerel (μBq) per day. The horizontal axis shows the age of the individuals tested with separate symbols for males and females.

There is no evidence of incremental intakes of plutonium associated with resettlement of Enewetak Island.

Previous estimates of the background excretion rates of plutonium by adults in the northern Marshall Islands range from 1-2 μBq per day. Our results are consistently lower than these values. This implies that not only is the existing level of plutonium exposure on Enewetak very low but, for those individuals tested, it is unlikely that they have ever required a significant exposure to plutonium from all previous intakes. The data and information provided by the urinalysis program on Enewetak will eventually be used to develop a local baseline in order to more accurately assess the significance of plutonium intakes associated with resettlement of other parts of the atoll.

PROJECTED 70-Y DOSE TO ENEWETAK ISLAND RESIDENTS FROM INTERNALLY DEPOSITED PLUTONIUM (2001-2002).

Projected 70-y dose to Enewetak Island residents from internally deposited plutonium

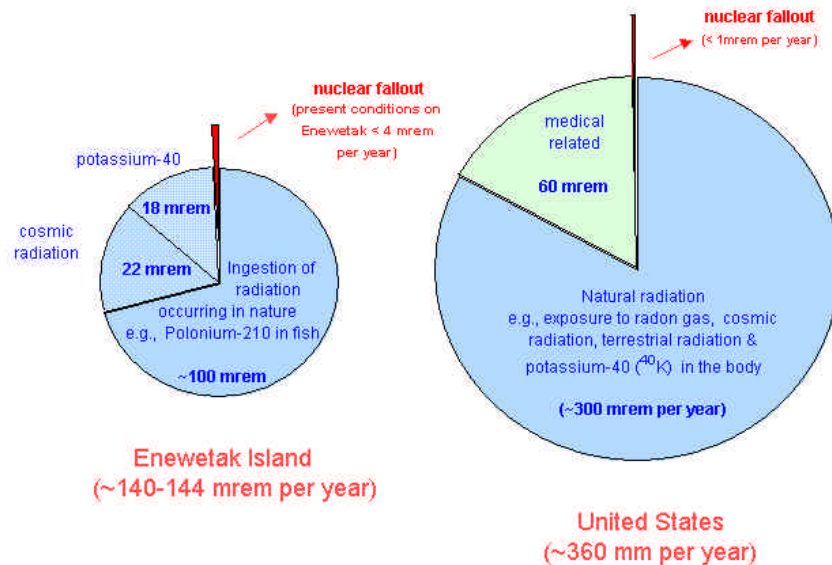


The amount of plutonium detected in bioassay samples collected from nearly 100 individuals during 2001-2002 fall at or below the critical level of detection for the measurements. This would normally negate the need to report a dose; rather, we would assume the dose from plutonium was zero. For completeness, dose estimates have been included in our reporting. The projected lifetime dose from exposure to plutonium for all individuals tested on Enewetak is below 10 mrem over 70 years.

The estimated doses pose no measurable or discernable health risk.

COMPARISON OF RADIATION DOSES IN THE MARSHALL ISLANDS AND UNITED STATES

Exposure to natural and man-made sources of radiation



The dose that people receive from ingestion of cesium-137 in locally grown foods needs to be put in perspective. For example, potassium is an essential element for life but happens to be partly radioactive. Naturally occurring potassium-40 in the body contributes about 14 mrem to our annual internal dose in the same manner as cesium-137. A standard medical X-ray contributes a dose of about 6 mrem.

The total natural background dose in the Marshall Islands is around 140 mrem per year and is derived largely from eating naturally occurring polonium-210 in fresh fish. People in the United States receive a much higher natural radiation dose of around 300 mrem per year. The overall health risk from radiation exposure is determined from the sum of the natural and manmade doses. The average estimated internal dose from cesium-137 measured in the body of people on Enewetak Island is much less than 1% of their total natural background dose.

The internal dose from cesium-137 on Enewetak Island is also well below the recommended cleanup standard of 15 mrem per year adopted by the Republic of the Marshall Islands. International agencies have adopted a much less stringent standard of 100 mrem per year above background for protection of members of the public.

GLOSSARY OF TERMS

Becquerel (Bq)

A Becquerel (abbreviated as Bq) is the International System (SI) unit for activity of a radioactive material. One Bq of radioactive materials is the amount of material in which one atom is transformed or undergoes one decay every second.

Calibration

The process of adjusting the response of an instrument to give accurate readings.

Critical Level

The amount or number of counts at or above which a decision is made that a radioactive material is definitely present.

Dose Equivalent

The dose equivalent is the dose taking into account the biological effectiveness of radiation to cause damage.

High End Health Risk

Relates to the maximally exposed individual in a population

Internal Dose or Exposure

That portion of the dose equivalent received from radiation sources inside the human body.

Individual

Any human being

Isotope

An atom of the same element having slightly different atomic mass. We identify different isotopes by appending a number relating the mass of the isotope to the name of the element. An example is cesium-137 which is often abbreviated as ^{137}Cs where the chemical symbol for cesium is Cs.

Quality Assurance

Actions taken to control a measurement process to ensure that they meet applicable standards.

Radiation Dose

Radiation dose is a generic term used to estimate radiation induced health risks and is usually expressed in units of mrem per year.

Radioactivity

A natural or spontaneous process by which unstable atoms of an element emit energy and/or particles, and change (or decay) to a different element or different isotopes of the same element.

Appendix 1

Individual Annual Dose Report

All volunteers receive an individual annual dose report during each year of participation in the whole body counting or plutonium urinalysis programs.

A sample of a dose report is shown below.

The report shows the annual dose the individual received during the year. This dose can be compared with a natural background dose of 140 mrem in the Marshall Islands (received by people in the Marshall Islands). The report also includes a copy of all verified measurement data used to calculate the dose.



Lawrence Livermore National Laboratory
HEALTH & ECOLOGICAL
ASSESSMENT DIVISION

October 21, 2001
Personal ID# «PersonallD»

TO: «FirstName» «LastName»
FROM: Dr. Terry Hamilton
Marshall Islands Program Leader
Lawrence Livermore National Laboratory
SUBJECT: Individual Radiation Monitoring Report

Dear participant,

I am pleased to enclose a copy of your individual radiation monitoring dose report for the period through 31 December 2001 (see enclosed).

The Department of Energy in cooperation with local technicians have provided routine monitoring of your internal dose (if any) from ingestion of cesium-137 by Whole Body Counting (WBC). These data have then been converted into a single annual internal dose as shown below. We have also collected urine samples from workers to monitor exposures to plutonium (if any) in the air that you breath. Where both measurements are available the annual internal dose shown is the sum (if the two dose estimates).

Your estimated annual internal dose for year 2001 was «Total_Dose_2001» millirem (mrem).

This is significantly lower than the dose limit in the United States of 100 mrem/year for members of the general public, and is less than the 15 mrem/year adopted by the Republic of the Marshall Islands.

Consequently, under your present living/working conditions you appear to be receiving adequate radiation protection.

Thank you for your participation.

Individual Radiation Monitoring Report

Personal ID	Last Name	First Name	Address
0000000	Doe	John	Lawrence Livermore National Laboratory P.O. Box 808 Livermore CA 94539 United States of America

Internal Dose Report

Year	Cesium-137		Plutonium-239		Plutonium-240	
	Annual Dose	CEDE*	Annual Dose	CEDE*	Annual Dose	CEDE*
	mrem	mrem	mrem	mrem	mrem	mrem
2001	15.0	21.0	0.00	0.0	0.00	0.0

*CEDE=Committed Effective Dose Equivalent over 70 years.

The amount of radiation a person receives is called the "effective dose equivalent" and is measured in thousandths of a rem (called the millirem) and is abbreviated or shortened to mrem. Your internal dose from ingestion of cesium-137 and inhalation of plutonium-239 has been converted into a single internal annual dose and a CEDE as shown above. This compares with an estimated Marshall Islands background dose of 140 mrem/year. The international scientific community has adopted the use of a different term for millirem called the millisievert (mSv). A millirem is the same as one-hundredth of a mSv.

Cesium-137 Internal Monitoring Data

Whole Body Counting (WBC)

Date of Count	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
5/21/01	Cesium-137	kBq	4.20	4.62	3.78
6/28/01	Cesium-137	kBq	4.20	4.62	3.78
9/10/01	Cesium-137	kBq	4.20	4.62	3.78
10/12/01	Cesium-137	kBq	4.20	4.62	3.78
12/12/01	Cesium-137	kBq	4.20	4.62	3.78

Plutonium Internal Monitoring Data

Plutonium Urinalysis (Pu in urine)

Date of Collection	Nuclide	Unit	Activity	Uncertainty Range	
				Maximum	Minimum
8/1/01	Plutonium-239	uBq/24 h void	0.0	0.0	0.0
8/1/01	Plutonium-240	uBq/24 h void	0.0	0.0	0.0

Plutonium analyses were performed by the Center for Mass Spectrometry at the Lawrence Livermore National Laboratory using the new state-of-the-art measurement technology Accelerator Mass Spectrometry (AMS). Accelerator mass spectrometry is about 100 times more sensitive compared with classical bioassay monitoring techniques. The results show that levels of plutonium in your urine are within the normal worldwide background range.